Activity and performance on a student-centred undergraduate mathematics course

Rämö, Johanna

University of Montpellier and INDRUM
2016

Rämö , J , Oinonen , L & Vihavainen , A 2016 , Activity and performance on a student-centred undergraduate mathematics course . in Proceedings of INDRUM 2016 : First conference of International Network for Didactic Research in University Mathematics . INDRUM Proceedings , University of Montpellier and INDRUM , Montpellier , pp. 494-503 , Conference of the International Network for Didactic Research in University Mathematics , Montpellier , France , 31/03/2016 .

http://hdl.handle.net/10138/303098

acceptedVersion

ACTIVITY AND PERFORMANCE ON A STUDENT-CENTRED UNDERGRADUATE MATHEMATICS COURSE

Johanna Rämö[1], Lotta Oinonen[1], and Arto Vihavainen[2]

University of Helsinki, [1]Deparment of Mathematics and Statistics / [2]Department of Computer Science, Finland, johanna.ramo@helsinki.fi.

This study investigated the connection between students' performance and activity for an introductory mathematics course organised using a student-centred teaching method. A relationship between performance and activity was found: the highest performing students reported that they attended drop-in sessions, worked with their peers, discussed with instructors, and attended lectures more than the weakest performing students. Moreover, students' motivations and learning strategies were related to their behaviour. The results suggest that it is important to provide the students with an accessible learning environment without time constraints, and offer them opportunities to collaborate with peers.

Keywords: student-centred, Extreme Apprenticeship, performance, attendance, Motivated Strategies for Learning.

INTRODUCTION

This study investigates the relationship between students' course performance and activity such as discussing with course instructors and working with peers. It focuses on an introductory mathematics course taught using a student-centred teaching method, Extreme Apprenticeship (Rämö, Oinonen, & Vikberg 2015; Vihavainen, Paksula, & Luukkainen, 2011). The core idea of the Extreme Apprenticeship method (XA) is to support students in becoming experts in their field by having them participate in activities that resemble those carried out by professionals. In mathematics this may mean, for example, reading mathematics, asking questions, discussing mathematical ideas and explaining one's reasoning. The theoretical background of XA is in Cognitive Apprenticeship (Brown, Collins, & Duguid, 1989). In the XA method, students learn skills and gain knowledge by working on tasks that have been divided into smaller and approachable goals, which are then merged together as the students start to master a topic. An important part of the teaching method is one-on-one instruction, and the students are also encouraged to work collaboratively. Bi-directional feedback between the instructor and the student plays a significant role: the students receive continuous feedback from their work, and at the same time the teachers receive feedback from the progress of the students, which can be used to craft materials and assignments that help students understand a topic.

In XA, studying revolves around working on tasks and discussing them with others. This means that the students' activity, such as attendance, help-seeking and collaboration is crucial. Several studies have found class attendance to be one of the main factors predicting performance (e.g., Credé, Roch, & Kieszczynka, 2010; Moore, 2006; Newman-Ford, Fitzgibbon, Lloyd, & Thomas, 2008). Reasons found for students' absenteeism are, among others, pressures from other courses (Van Blerkom, 1992), and not seeing a studied class as interesting or important (Moore, Armstrong, & Pearson, 2008; Gump, 2006).

In the XA method, help-seeking is a necessity for the student, as discussions with instructors and other students are an important part of teaching. Help-seeking has been studied extensively among younger students in school context, and many of the results have been confirmed in higher education settings. Poor self-esteem or low perceptions of their cognitive competence can make students feel that help-seeking is threatening (Karabenick & Knapp, 1991; Newman, 1990; Ryan & Pintrich, 1997). Also, in classrooms where students felt that the focus is on understanding and mastery, and not as much on competition and proving one's ability, students were less likely to avoid help-seeking (Karabenick, 2004; Ryan, Gheen, & Midgley, 1998). Karabenick and Knapp (1991) have shown that students are more likely to ask for help from their peers than their teachers. Also the social climate of the classroom may have an effect: positive relations have been found to increase the likelihood that students ask for help from the teacher or from their peers (Newman & Schwager, 1993). Symonds, Lawson, and Robinson (2008) have studied university students' help-seeking in mathematics support centres. They noticed that a large portion of students who need support do not seek it. Among the reasons were lack of awareness of the need of support, lack of motivation, time-management issues, and embarrassment.

CONTEXT AND DATA

Context: The course "Introduction to university mathematics"

The participants of this study were students of an introductory mathematics course "Introduction to university mathematics", which is a compulsory course to mathematics and computer science students. It lasted for 12 weeks, and introduced basic concepts such as sets, functions and relations, and familiarised the students with the concept of proof and various proving techniques. There were 569 students enrolled for the course, 44% of which were computer science students, 34% mathematics students and 6.8% statistics students. The course was taught with the Extreme Apprenticeship method. The teaching consisted of weekly tasks, one-on-one guidance and lectures. There was also a course material written by the teacher responsible for the course.

The students were given approximately 13 tasks per week, two of which were selected for inspection. Students received written feedback on their reasoning and readability of the solution, and were asked to improve their solutions when necessary. The students were awarded bonus points for completing the tasks. Guidance in solving the tasks and reading the course material was offered in daily drop-in sessions by instructors and the teacher responsible for the course. The students could come to the drop-in sessions when it suited them, and spend there as much time as they wished. There were three lectures per week, and their role was to model the problem solving processes of mathematicians, and link the concepts of the course together. Neither attending the lectures nor completing the course assignments was mandatory. The course was assessed using a midterm exam and a final exam, both having an equal contribution to the final grade of the students.

Several arrangements were made to make it as easy as possible for the students to seek help. The drop-in sessions were organised in a collaborative learning space where guidance was offered approximately 20 hours per week. The learning space is an open space in the main corridor of the department, close to classrooms, school office and the student common room. This means that the students walk through it several times during the day, and it should very feasible for them to sit down and start working. The instructors wear bright coloured vests, so that it is clear to the students who the teachers are. The tables in the learning space are arranged into groups and act as whiteboards, and the walls are covered with blackboards for the students to share their thoughts with each other and with the instructors.

The instructors were undergraduate and graduate students who were chosen via an interview. Students were used as instructors as there are indications that they are easier to approach than, for example, professors (Fingerson & Culley, 2001). During the course, the instructors went through training by taking part in weekly meetings. In the meetings, pedagogical aspects were discussed, such as how to interact with the students and how to guide them without giving away the answers. The instructors were advised that many of the students do not ask for help even when they need it, and therefore they should walk around and approach the students on their own initiative. Also, the instructors were informed of the importance of encouraging the students.

Data

Participants for this study were students of the course Introduction to university mathematics, which was organised at the University of Helsinki in autumn 2014. To measure attendance, students were asked to answer a short questionnaire regarding their activity during each week as they returned their coursework. The students were asked whether they (1) took part in the drop-in sessions, (2) talked to the instructors, (3) worked together with their peers or (4) attended the lectures at least once during the week. All in all, each student could return up to 12 weeks worth of coursework including weekly activity details.

In addition to answering the questionnaires regarding attendance and activity, the students were given the Motivated Strategies for Learning Questionnaire, MSLQ (Pintrich, Smith, Garcia, & McKeachie, 1993), which is a validated instrument for assessing students' learning strategies and motivations. The students completed the questionnaire in three phases during the three weeks following the midterm exam. Answering was not compulsory, but students gained bonus points for completing the questionnaire.

RESEARCH QUESTIONS AND METHODOLOGY

Our research questions for this study are the following:

RQ1: How is the students' course performance related to activity?

RQ2: How are the MSLQ factors linked to the students' activity and performance?

For the purposes of this study, we define course performance as total points in the two course exams. Activity is measured through multiple factors: (1) attendance in drop-in sessions, (2) discussing with course instructors, (3) discussing and working with peers, (4) lecture attendance, and (5) returning coursework. We restrict the analysis to the population of those 405 students who gained at least one point in total from the course exams.

RESULTS

Activity and Course Performance

To assess the relationship between course performance and activity, the participants were divided into four quartiles based on their performance in the midterm and final exams. As seen in Table 1, an increasing trend is observable in all of the activity-related categories, and the students in the highest performing quartile are the most active ones across the board.

		Q1	Q2	Q3	Q4	All
	Points	< 19.25	< 28.75	< 37.5	≥ 37.5	1-48
	Students	100	102	98	105	405
Attendance in drop-in sessions	Mean	2.0	3.6	5.4	6.9	4.5
	Std. dev.	2.5	3.6	4.3	4.3	4.1
Discussing with course instructors	Mean	1.0	2.0	3.8	3.8	2.7
	Std. dev.	1.6	3.0	4.0	3.9	3.5
Working with peers	Mean	1.7	3.4	4.6	5.8	3.9
	Std. dev.	2.4	3.6	4.3	4.5	4.1
Lecture attendance	Mean	2.3	4.9	6.7	7.6	5.4
	Std. dev.	2.5	4.0	4.2	3.9	4.2
Returning coursework	Mean	3.8	7.1	9.0	10.4	7.9
	Std. dev.	3.7	3.9	3.5	2.6	4.2

Table 1: Course performance and activity. The participants were divided into four quartiles based on their performance in the midterm and final exams, and the reported activity for each quartile is shown separately.

On average, students in the highest performing quartile reported having come to the drop-in sessions during 6.9 weeks out of the possible 12, whereas in the lowest performing quartile the corresponding number was only 2.0. In what comes to other types of activity, the trend was similar: Students in the highest performing quartile reported having discussed with instructors during 3.8 weeks compared to 1.0 week in the lowest performing quartile. The highest performing group reported having worked with peers on average during 5.8 weeks, and the lowest performing group during 1.7 weeks. Students in the highest performing quartile reported having attended lectures on average during 7.6 weeks, and in the lowest performing quartile during 2.3 weeks. Coursework was submitted on average during 10.4 weeks in the highest performing quartile, whereas in the weakest performing quartile this happened only during 3.8 weeks.

The standard deviations within the quartiles are high, and Mann Whitney U Test was conducted to determine whether the quartiles differ from each other. It was found that all the quartiles differ significantly from each other ($p < 0.05$) except for the following cases: The quartiles Q3 and Q4 were similar in how often students reported having discussed with an instructor ($p = 0.7742$), worked with peers ($p = 0.0971$), and attended the lectures ($p = 0.1555$). The quartiles Q1 and Q2 were similar in how often students reported having discussed with an instructor ($p = 0.0502$). This means that the highest and lowest performing students differ from each other in what comes to activity and attendance.

Motivated Strategies for Learning and Activity

To assess the relationship between learning strategies and motivations, and the students' activity, the students were asked to complete the Motivated Strategies for Learning Questionnaire. From the 405 students, 164 students completed the full questionnaire. When comparing the performance of the population who answered the questionnaire and the population who did not answer the questionnaire, there is a statistically significant difference between the groups ($p < 0.05$). When combining the quartiles 2, 3 and 4 from the previous section, and comparing their performance to the population that answered the questionnaire, no significant difference exists ($p > 0.05$). This indicates that the following results are related to a population that performed better than the overall population.

Table 2 shows Pearson's correlation coefficient between different MSLQ factors and different types of activity. The following moderate (>0.3) or strong (>0.5) correlations were found: The factors help-seeking and peer learning correlate with collaborative activity of the students (attendance in drop-in sessions, discussing with course instructors, and working with peers). The factors effort regulation, help-seeking, and time and study environment management correlate with lecture attendance and returning coursework. The factors effort regulation, time and study environment management, control of learning beliefs, intrinsic goal orientation, self-efficacy, task value, and test anxiety correlate with exam points.

	Attendance in drop-in sessions	Discussing with course instructors	Working with peers	Lecture attendance	Returning coursework	Exam points total
Critical thinking	0.161 *	0.082	0.060	0.062	0.051	0.121
Effort	0.258 **	0.219 **	0.114	**0.309 ****	**0.359 ****	**0.391 ****

regulation						
Elaboration	0.227 **	0.201 **	0.119	0.225 **	0.071	0.029
Help-seeking	**0.520 ****	**0.473 ****	**0.642 ****	**0.316 ****	**0.303 ****	0.082
Metacognitive self-regulation	0.061	0.028	–0.026	0.108	0.088	0.188 **
Organization	0.150 *	0.128 *	0.026	0.139	0.056	0.018
Peer learning	**0.450 ****	**0.355 ****	**0.627 ****	0.289 **	0.210 **	0.045
Rehearsal	0.030	0.030	–0.039	0.145 *	0.101	-0.050
Time and study environment management	0.281 **	0.269 **	0.125	**0.484 ****	**0.481 ****	**0.309 ****
Control of learning beliefs	–0.043	–0.094	-0.132 *	–0.122	0.012	**0.303 ****
Extrinsic goal orientation	0.201 *	0.134 *	0.149 *	0.210 **	0.223 **	0.237 **
Intrinsic goal orientation	0.041	0.025	–0.062	–0.007	0.063	**0.307 ****
Self-efficacy	0.241 **	0.171 **	0.112	0.127	0.297 **	**0.687 ****
Task value	0.194 **	0.214 **	–0.050	0.123	0.181 **	**0.389 ****
Test anxiety	–0.127	–0.126	0.004	0.000	–0.152 *	**-0.317 ****

Table 2: Pearson's correlation coefficients between MSLQ factors and students' activity (* $p < 0.05$; ** $p < 0.01$). The coefficients larger than 0.3 are emboldened.

DISCUSSION

This study addressed the connections between students' activity and their course performance, and identified MSLQ factors that are related to activity and performance. A connection between performance and activity is visible: the highest performing students reported that they attended drop-in sessions, worked with their peers, discussed with instructors, and attended lectures more than the weakest performing students. The results are in line with previous findings linking lecture and classroom attendance with performance (e.g., Moore, 2006; Newman-Ford, Fitzgibbon, Lloyd, & Thomas, 2008). In addition, the results show that also other kind of activity than lecture or classroom attendance is linked to the performance of students. This indicates that it is important to have the students participate and interact with each other and the teaching staff.

The standard deviations of activity within the four quartiles were high. This can be explained by the heterogeneous student population: for example, many of the high performing students never attend instruction as they do not need it, and at the same time some of the poorly performing students show grit by working hard even though they may not pass the course at the first attempt. Even though the standard deviations were high, the highest and lowest performing students differed from each other in what comes to their activity.

The average activity of the students was relatively low. In the case of the highest performing students, low averages can be explained by the students being able to complete the coursework on their own. Also, many of the mathematics students find social encounters difficult, and may therefore avoid, for example, coming to drop-in sessions. In addition, there are relatively many students who work alongside their studies and cannot therefore attend even if they wish to do so. One should also note that the majority of the participants were not mathematics, but computer science or statistics students whose motivation to study mathematics may be low and background knowledge insufficient. Had we investigated mathematics students only the numbers would probably look different. All in all, the results show that more work needs to be done in encouraging the students to participate.

The MSLQ factors give us insight into the reasons behind students' activity and attendance. Students' collaborative activity (i.e. attending drop-in sessions, discussing with instructors and working with peers) was related to the MSLQ factors help-seeking and peer learning. This indicates that the XA method enables interaction with instructors and other students for those students who use help-seeking and peer learning as learning strategies. On the other hand, the MSLQ factors effort regulation and time and study management correlated only weakly with students' self-reported attendance in the drop-in sessions and interaction with instructors, but they were linked to lecture attendance. It seems that in order to attend the drop-in sessions, the students do not need to have high skills in managing their time or controlling their effort and attention. This indicates that the XA drop-in sessions have, to some extent, managed to overcome the time management and motivational issues mentioned in previous studies as a reason for the classroom absenteeism of students (Van Blerkom, 1992; Moore, Armstrong, & Pearson, 2008; Gump, 2006) and for them not seeking for help (Symonds, Lawson, & Robinson, 2008). We suggest that the teaching arrangements and the learning environment created for XA make this possible: the students can come to the drop-in sessions when they want and the learning space is in the middle of the department and easy to access.

One type of collaborative activity, namely working with peers seems to be special. Many of the MSLQ factors that correlate with attending drop-in sessions and discussing with course instructors do not correlate with working with peers. Such factors are effort regulation, elaboration, time and study environment management, self-efficacy, and task value. This indicates that students work with their peers even though they do not, for example, perceive themselves very good at time management, have low expectations of their ability to accomplish tasks or do not find the course useful. These findings are in line with the results of Karabenick and Knapp (1991) showing that students are more likely to ask for help from their peers than their teachers. This implies that it is important to offer students opportunities to work with their peers. Also, from this view, using undergraduate students as instructors could have benefits, as the students who otherwise tend to avoid help-seeking may find it easier to communicate with an instructor who is almost like a peer to them. This is in agreement with the findings of Fingerson and Culley (2001).

It is known from previous research that low self-efficacy can prevent students from asking for help (Karabenick & Knapp, 1991; Newman, 1990; Ryan & Pintrich, 1997). However, in our study, correlations between self-efficacy and attending drop-in sessions, discussing with instructors or working with peers were relatively small. We suggest that the XA method encouraged the students to seek for help despite of their low self-efficacy. There are several features in XA that contribute towards this aim. According to Newman and Schwager (1993), positive relations with teachers can increase the likelihood of students asking for help, and in the XA method the instructors are advised to approach the students, chat with them and be supportive. Also, there are indications that if the classroom's focus is on understanding and mastery, students are less likely to avoid help-seeking (Karabenick, 2004; Ryan, Gheen, & Midgley, 1998). Indeed, in the XA method emphasis is on mastery rather than proving one's ability. For example, students can resubmit their coursework if their solution is incorrect, and this does not affect the bonus points awarded.

There were some limitations in our study in what comes to measuring the activity of the students. Firstly, students may have different views on what the questions mean. For example, does asking one simple question count as discussing with an instructor? Secondly, our data only shows whether students reported having been active during the week, not the amount of time they devoted to different activities each week. Despite of this limitation, the data give an indication of the perseverance with which the students worked during the course.

There was a noticeable answer bias in the MSLQ, as only a handful of the students who were in the lowest performing quartile completed it. This can, to some extent, be explained by the fact that the MSLQ was given to the students after the first midterm exam, and at that point many of the lowest performing students had probably decided to quit the course and therefore did not answer the questionnaire. The bias means that we cannot draw conclusions on the whole population.

As the students completed the MSLQ after the midterm exam, one cannot say for sure whether the students' answers have been influenced by the teaching methods of the course. A direction for future research would be to give the MSLQ to the students both at the beginning and at the end of the course to see how their perceptions change when they are exposed to the Extreme Apprenticeship method.

REFERENCES

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, *18*(1), 32–42.

Credé, M., Roch, S.G., & Kieszczynka, U.M. (2010). Class Attendance in College: A Meta-Analytic Review of the Relationship of Class Attendance with Grades and Student Characteristics. *Review of Educational Research, 80*, 272–295.

Fingerson, L., & Culley, A.B. (2001). Collaborators in Teaching and Learning: Undergraduate Teaching Assistants in the Classroom. *Teaching Sociology, 29*, 299–315.

Gump, S.E. (2006). Guess Who's (Not) Coming to Class: Student Attitudes as Indicators of Attendance. *Educational Studies, 32*, 39–46.

Karabenick, S.A. (2004). Perceived Achievement Goal Structure and College Student Help Seeking. *Journal of Educational Psychology, 96*, 569–581.

Karabenick, S.A., & Knapp, J.R. (1991). Relationship of Academic Help Seeking to the Use of Learning Strategies and Other Instrumental Achievement Behavior in College Students. *Journal of Educational Psychology, 83*, 221–230.

Kitsantas, A., & Chow, A. (2007). College Students' Perceived Threat and Preference for Seeking Help in Traditional, Distributed, and Distance Learning Environments. *Computers & Education, 48,* 383–395.

Moore, R. (2006). The Importance of Admissions Scores and Attendance to First-Year Performance. *Journal of the First-Year Experience & Students in Transition, 18*, 105–125.

Moore, S., Armstrong, C., & Pearson, J. (2008). Lecture Absenteeism among Students in Higher Education: A Valuable Route to Understanding Student Motivation. *Journal of Higher Education Policy and Management, 30*(1), 15–24.

Newman, R.S. (1990). Children's Help-Seeking in the Classroom: The Role of Motivational Factors and Attitudes. *Journal of Educational Psychology, 82*, 71–80.

Newman, R.S., & Schwager, M.T. (1993). Students' Perceptions of the Teacher and Classmates in Relation to Reported Help Seeking in Math Class. *The Elementary School Journal, 94*, 3–17.

Newman-Ford, L., Fitzgibbon, K., Lloyd, S., & Thomas, S. (2008). A Large-scale Investigation into the Relationship between Attendance and Attainment: A Study Using an Innovative, Electronic Attendance Monitoring System. *Studies in Higher Education, 33*, 699–717.

Pintrich, P.R., Smith, D.A.F., Garcia, T., & McKeachie, W.J. (1993). Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement, 53*, 801–813.

Ryan, A.M., Gheen, M.H., & Midgley, C. (1998). Why Do Some Students Avoid Asking for Help? An Examination of the Interplay among Students' Academic Efficacy, Teachers' Social-Emotional Role, and the Classroom Goal Structure. *Journal of Educational Psychology, 90*, 528–535.

Ryan, A.M., & Pintrich, P.R. (1997). "Should I Ask for Help?" The Role of Motivation and Attitudes in Adolescents' Help Seeking in Math Class. *Journal of Educational Psychology, 89*, 329–341.

Rämö, J., Oinonen, L., & Vikberg, T. (2015). Extreme Apprenticeship – Emphasising Conceptual Understanding in Undergraduate Mathematics. In K. Krainer & N. Vondrová (Eds.), *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education* (pp. 2242–2248). Prague: Charles University in Prague, Faculty of Education and ERME.

Symonds, R., Lawson, D., & Robinson, C. (2008). Promoting Student Engagement with Mathematics Support. *Teaching Mathematics and Its Applications, 27*, 140–149.

Van Blerkom, M.L. (1992). Class Attendance in Undergraduate Courses. *The Journal of Psychology, 126*, 487–494.

Vihavainen, A., Paksula, M., & Luukkainen, M. (2011). Extreme Apprenticeship Method in Teaching Programming for Beginners. In *Proceedings of the 42nd ACM Technical Symposium on Computer Science Education* (pp. 93–98). ACM.